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Emergency lighting, safety lighting

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[Titel+01] During a power failure, no electricity means no lighting. In places of assembly, schools, hospitals, etc., mains-independent emergency and safety lighting now needs to kick in to make it possible for people to leave the building safely. The light it provides facilitates orientation and reduces risk of accident.

01

Emergency lighting provides safety

Anyone looking for information about power outages in Germany needs to consult the “Availability Statistics” published by the association of German electricity network operators (VDN) within the German Energy and Water Association (BDEW). This is where the power industry keeps a tally of “incidents”, by which it generally means mains power failures.

Power failures

Two “extreme incidents” are imprinted on many Germans’ memory. In November 2005, masts carrying overhead power lines in the Münster area collapsed under the weight of snow and ice, causing a blackout that lasted more than four days. A year later, on 4 November 2006, an event in the Emsland area gave rise to a power outage that left large parts of Europe without electricity for a number of hours: a high-tension cable was shut down to allow a cruise vessel to sail down the Ems River from the Meyer shipyards at Papenburg to the North Sea.

But most power outages are more localised affairs and do not last hours. Germany has the best record in Europe for reliable power supply. However, the number of outage incidents is rising – and the causes are diverse: a violent storm, high winds, earthworks/excavation operations, a fire and a system overload accounted for just five of 27 power failures.

Emergency and safety lighting

No electricity means no lighting. This is when mains-independent emergency lighting needs to kick in. Panic spreads quickly in a building suddenly plunged into darkness – especially if there are many people present and some are not familiar with the surroundings. A blackout in an unknown place for an unknown reason sparks fear. To facilitate orientation and reduce risk of accident, routes out of the building should be marked by a supplementary system of escape route luminaires.

Safety lighting is a must. Where emergency lighting is required, responsibility for installing and maintaining it resides with the operator of the establishment; ensuring that a new or modernised installation complies with regulations is the responsibility of the designer. Failure to comply with the stipulations set out in standards may be judged hazardous building practice, which is an offence punishable under paragraph 319 of the German Criminal Code.

Despite harmonisation efforts, the rules about where emergency lighting is required still differ – in some cases from one part of Germany to another but, in particular, between Germany and other member states of the European Union (EU). Here are two examples:

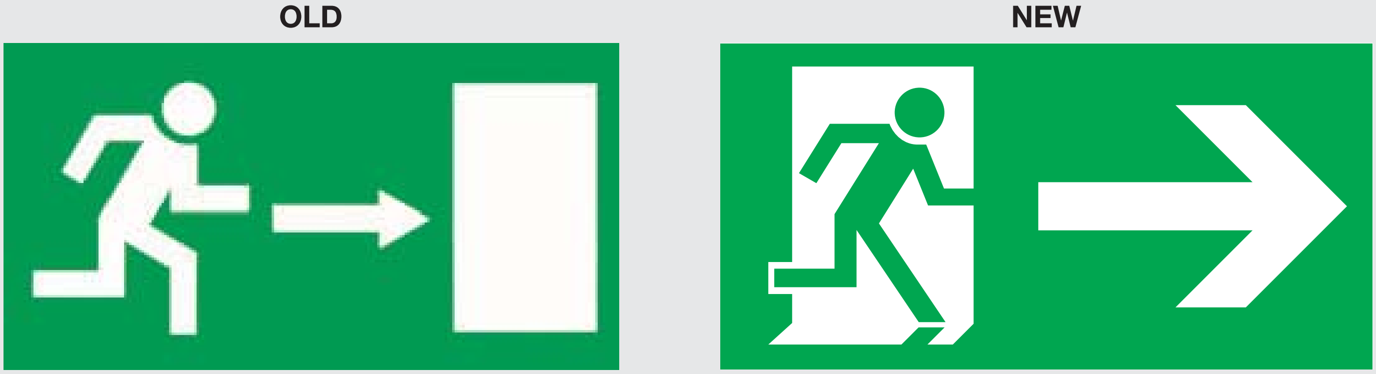
> In Germany, emergency lighting is not currently required for retirement homes; in Finland, Holland, Italy, Sweden and Spain, it needs to be installed regardless of the scale of the establishment or the number of beds.
> In Germany and Austria, emergency lighting is required only for sales premises over 2,000 m². In Belgium, Finland and Sweden, blanket regulations are in place.

Comparison shows (“Emergency lighting in Europe”, see “Standards, literature”, page 38) that Germany has few general requirements for emergency lighting and the thresholds above which emergency lighting is mandatory are relatively generous. There is no requirement, for example, for small or medium-scale enterprises to install emergency lighting. So the safety of people working there is not guaranteed in the event of a power failure. In terms of emergency lighting standards required by building regulations, Germany ranks behind most of the EU.

02

New escape sign

A white stick man on a green background or a green man on a white background? There are two escape signs around now. But which one is correct? The old sign (left) naturally remains valid but new emergency lighting systems should display the new symbol (right). licht.de advises against mixing old and new signs in an existing system.



03

[02] Wherever a power failure occurs, hazard potential is increased. Sudden darkness sparks fear: the reason for the blackout is unknown and even people familiar with the building find it difficult or impossible to get their bearings. In many buildings it is therefore mandatory that escape routes should be marked by mains-independent lighting and a supplementary safety lighting system should be installed.

When power systems fail

When the general artificial lighting fails after a power outage, the emergency lighting system takes over. Where there is a risk of accident after a power failure, the safety lighting needs to be activated.

Emergency lighting is not only used for bridging gaps in general power supply; it also helps in other emergencies. If a building needs to be evacuated, for example, emergency lighting plays a key role in helping people get their bearings and find their way along escape routes to safe areas.

Emergency lighting includes

> safety lighting and
> standby lighting.

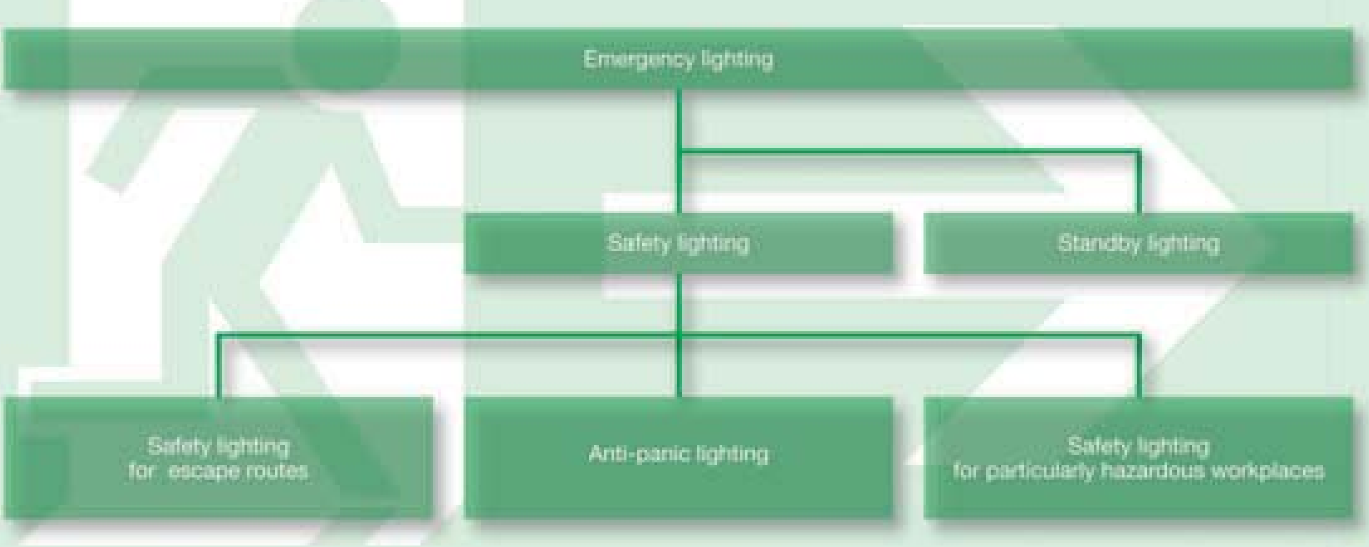
Safety lighting, in turn, is divided into
> safety lighting for escape routes including escape route signs,
> anti-panic lighting and
> safety lighting for particularly hazardous workplaces.

DIN EN 1838 sets out the requirements for safety lighting in emergency operation, i.e. in the event of a power failure; DIN 4844 deals with the *lighting requirements* for safety signs during normal mains operation.

The *electrical requirements* for system planning, installation and operation are contained in E DIN VDE 0108-100 (for information [in German] about the current status of normative requirements, see www.dke.de, search term “Sicherheitsbeleuchtungsanlagen”) and the current draft standards relating to it (see “Standards, literature”, page 38).

The *safety and electrical requirements* that need to be met by luminaires for emergency lighting systems are defined in DIN EN 60598-2-22.

Types of emergency lighting


Emergency lighting
Safety lighting
Standby lighting
Safety lighting for escape routes
Anti-panic lighting
Safety lighting for particularly hazardous workplaces

04

05

[05] In the event of a building being evacuated, correctly illuminated and identified escape routes play an important role in helping people get to safety.

Technical regulations for emergency lighting

	electrical	non-electrical/ lighting	
International	IEC	ISO / CIE	
Europe	CENELEC	CEN	EU directive
Germany	DIN / VDE	DIN	German law

IEC = International Electrotechnical Commission
CENELEC = Comité Européen de Normalisation Electrotechnique (European Committee for Electrotechnical Standardisation)
DIN = Deutsches Institut für Normung (German Standards Institute)
VDE = Verband der Elektrotechnik, Elektronik und Informationstechnik (Association for Electrical, Electronic & Information Technologies)
ISO = International Organization for Standardization
CIE = Commission Internationale de l'Éclairage (International Commission on Illumination)
CEN = Comité Européen de Normalisation (European Committee for Standardisation)

Safety lighting

Safety lighting is always needed where failure of general lighting presents a risk of accidents

Safety lighting is divided into

- safety lighting for escape routes, including escape route signs
- anti-panic lighting
- safety lighting for particularly hazardous workplaces.

The purpose of safety lighting during a general power failure is
- to make it possible for people to *evacuate the premises safely*;
- to enable *potentially hazardous* work operations to be safely terminated.

The most important features of safety lighting:

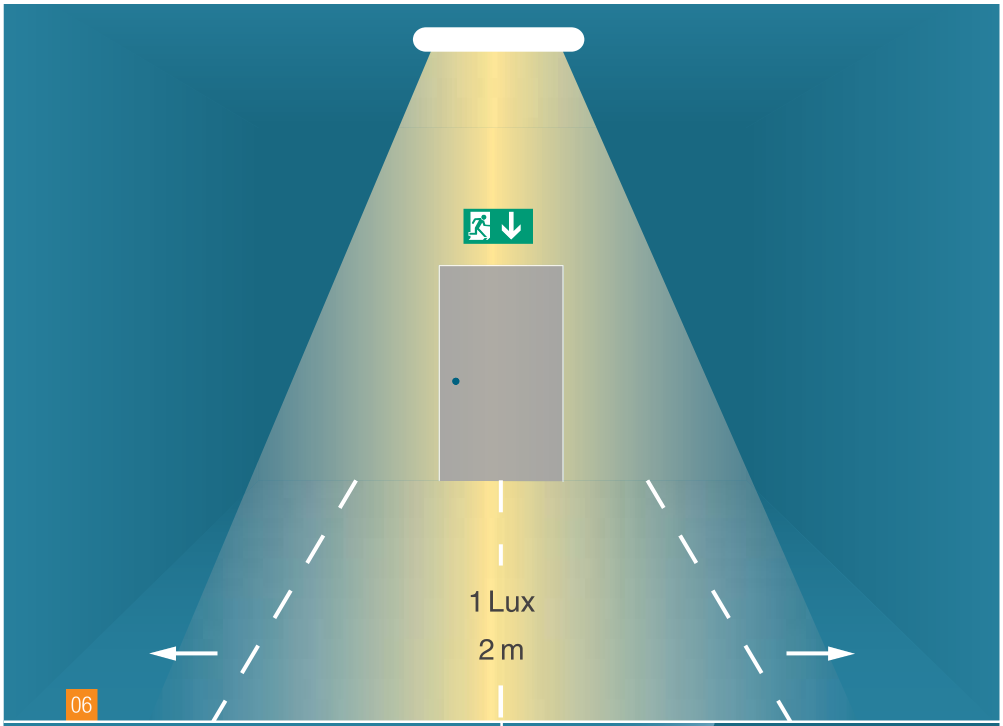
- luminaires are mounted *at least 2 metres* above floor level;
- escape signs at emergency exits and at exits along escape routes are all *illuminated or back-lit*;
- if an emergency exit is not directly visible, one or more illuminated and/or back-lit escape signs need to be positioned along the escape route.

In addition to general illumination of the escape route, DIN EN 1838 stresses the need for illumination at special points, such as potential hazard sites. Safety luminaires for this purpose need to be positioned at the following points:
- at exit doors for emergency use
- near stairs, single steps or any other change of level
- at prescribed emergency exits and safety signs
- at any point where there is a change of direction
- at any point where corridors cross
- near any First Aid post, fire-fighting facility or alarm device
- near final exits
- outside the building near every final exit.

"Near" means no more than 2 metres away.

A selection of key laws and ordinances

National Building Regulations	**Occupational safety**
Ordinance Governing Places of Assembly (VStättVO) Ordinance Governing Sales Premises (MvkVO) Ordinance Governing Accommodation Establishments (BeVO) Ordinance Governing High-rise Buildings (HochhausVO) Ordinance Governing Garages (GarVO) Guideline for School Buildings (SchulbauR) Ordinance Governing Hospital Buildings (KhBauVO) Model Guideline on Fire Protection Requirements for Conduction Systems (MLAR) Ordinance Governing Electrical Operating Areas (EltBauVO)	Occupational Safety Act (ArbSchG) Workplace Ordinance (ArbStättVO) Workplace regulations (ASR) Health and safety rules (BGR)



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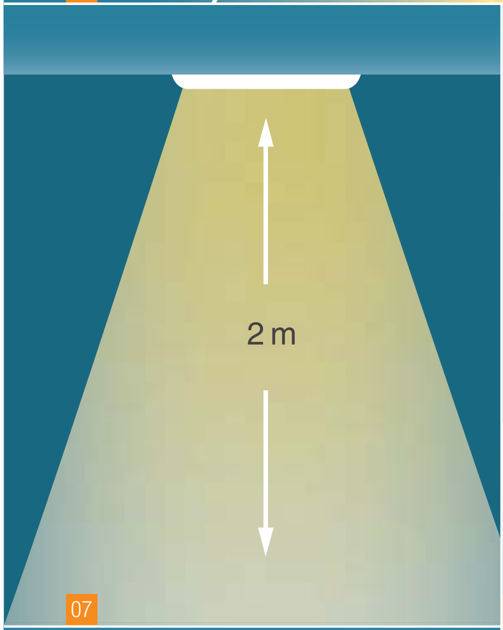

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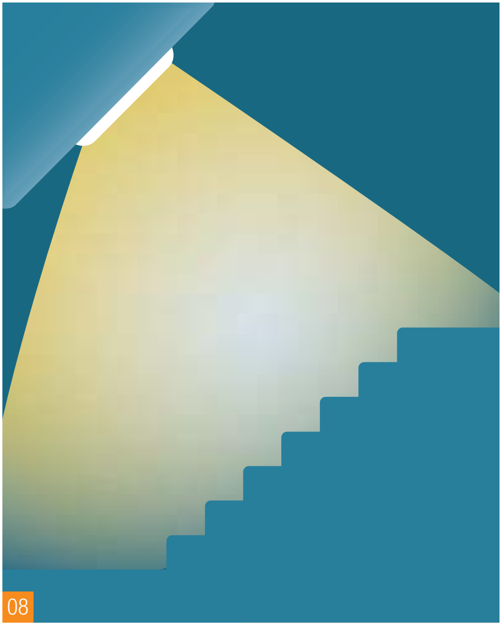

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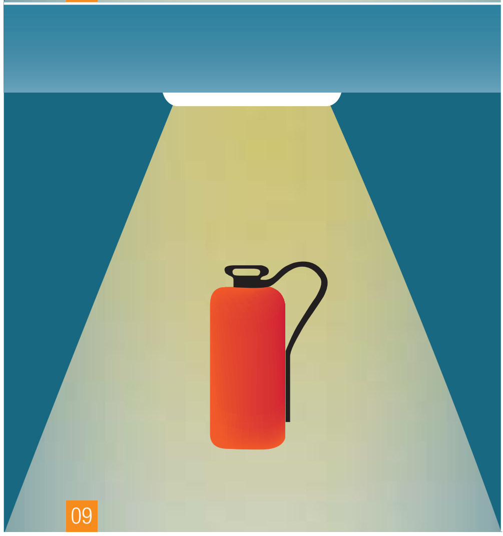

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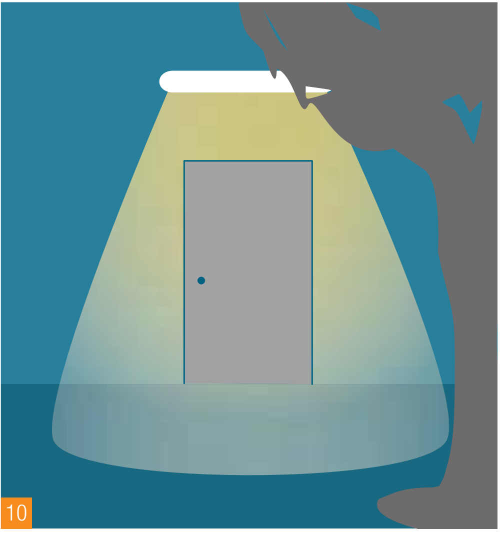

10

[06] On escape routes up to 2 metres wide, the horizontal illuminance on the central axis must be at least 1 lx (measured at height of max. 2 centimetres).

Among other things, luminaires for safety lighting need to be positioned …

[07] … at least two metres above floor level;

[08] … near (max. 2 metres from) stairs to ensure direct illumination of each tread;

[09] … near (max. 2 metres from) any First Aid post, fire-fighting facility or alarm device.

[10] … outside the building near (max. 2 metres from) every final exit.

Escape route safety lighting

If escape route safety lighting is to fulfil its purpose, it needs to ensure adequate conditions for visual orientation on escape routes and in adjoining areas of the building. At the same time, alarms and fire-fighting equipment need to be easy to locate and use.

Lighting and signs are vital for safety on escape routes

They must always include:

> escape sign luminaires or illuminated escape signs for *marking* the escape route as well as
> luminaires for *illuminating* the route

What is more, all employers are required to position escape and rescue plans where they are clearly visible to everyone: employees must have a chance to memorise escape and rescue routes so that emergency stairs and emergency exits can always be found. Escape and rescue plans also serve as an orientation aid for emergency services such as the fire service.

According to DIN EN 1838, escape route safety lighting forms part of the safety lighting system, enabling emergency facilities to be clearly identified and safely used where persons are present. On escape routes up to two metres wide, the horizontal illuminance on the central axis needs to be at least 1 lx – measured at a height of no more than two centimetres.

Lighting uniformity

In addition, the ratio of highest to lowest illuminance along the central axis must not exceed 40:1 – not even in the worst-case scenario between two luminaires at the end of the nominal operating time. This is because excessively bright/dark patches make obstacles and the escape route ahead harder to make out.

The time lag between the moment the general artificial lighting fails at the start of a power outage and the moment the required illuminance is reached should be as short as possible. The nominal operating time of safety lighting for work premises needs to be guaranteed for at least an hour. The table on page 35 shows the times required on other premises.

To ensure that safety colours can be clearly identified, the colour rendering index R_a must be at least 40.

Glare limitation - an often underestimated factor

Excessively intense light can cause physiological (disability) glare. In escape route lighting, it presents a problem in that it prevents obstacles or signs being seen. The risk is particularly acute where general diffuse lamps are used.

In the case of horizontal escape routes, luminous intensity must not exceed certain limits at any azimuth angles between 60° and 90° to the vertical. For all other escape routes and zones, the limits must not be exceeded at any angle (see illustrations).

Escape route signage is also important. The lighting requirements in the event of a power failure are set out in DIN EN 1838. It should also be noted that the escape sign luminaires defined in DIN 4844 must be clearly identifiable even under general lighting conditions and therefore need to be operated at a higher luminance level. For emergency operation, the luminance at any point on the green surface should be ≥ 2 cd/m²; for mains operation, the average luminance of the entire sign should be ≥ 200 cd/m² (see also “Safety signs: quality is crucial” on page 14).

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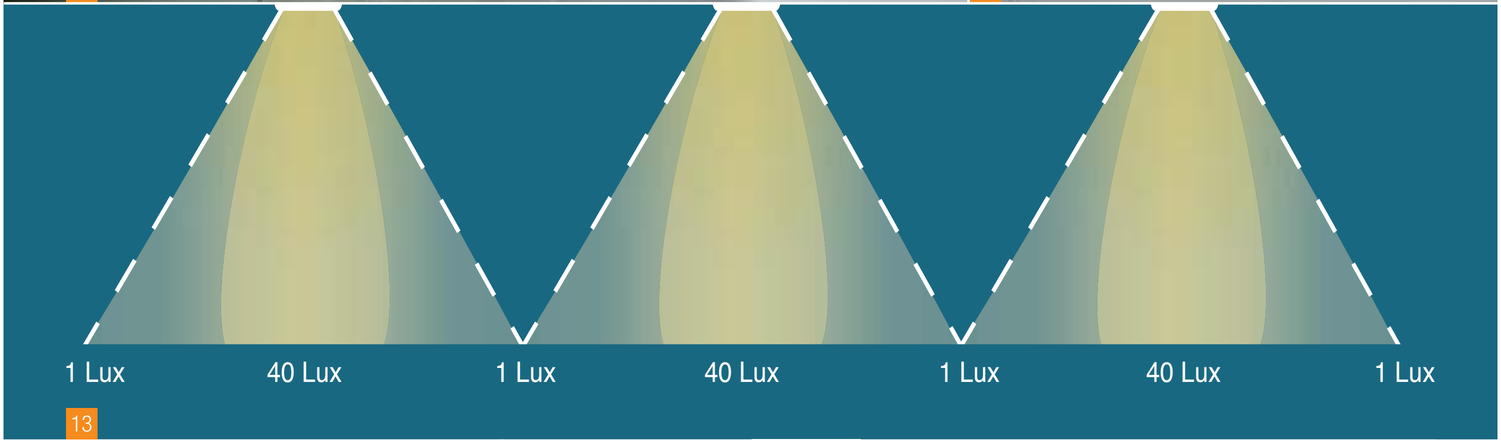

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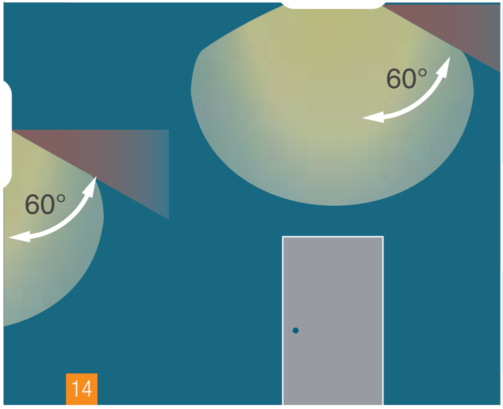

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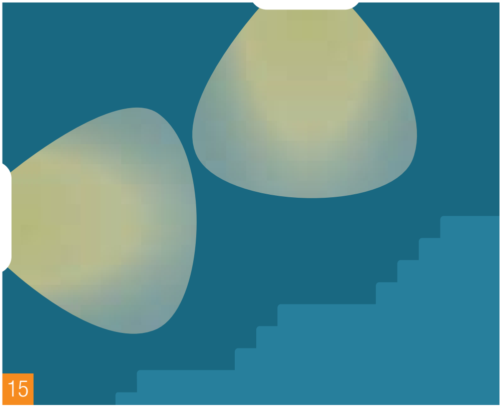
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[11+12] Escape route marking is also important.

[13] The ratio of the highest to lowest illuminance along the central axis must not exceed 40:1. This avoids excessive light/dark contrasts that interfere with the visual task.

[14] In the case of horizontal escape routes, luminous intensity must not exceed certain limits at any angles between 60° and 90° to the vertical.

[15] For all other escape routes and zones, the limits must not be exceeded at any angle.

Where escape route safety lighting is required, the old workplace regulation ASR 7/4 still applies. “Safety and health signs” are covered by the technical regulation ASR A1.3, “Escape routes, emergency exits, escape and rescue plan” are described in ASR A2.3.

According to the old ASR 7/4, escape route safety lighting may be required in

> work and storage rooms with a floor area of 2,000 m² or more;
> work and break rooms where the floor is 22 metres above ground level;
> particularly hazardous laboratories with a floor area of 600 m² or more. Where the area is between 30 and 600 m² , it is enough to mount escape sign luminaires at the exits visible from each workplace;
> work rooms with explosive and toxic atmospheres and a floor area of 100 m² or more. In rooms of 30 to 100 m² , it is enough to mount escape sign luminaires at the exits visible from each workplace;
> work rooms without daylight with an area of 100 m² or more. In rooms of 30 to 100 m², it is enough to mount escape sign luminaires at the exits visible from each workplace;
> and on the relevant escape routes.

Escape route safety lighting (DIN EN 1838)

Illuminance:	E_{min} = 1 lx E_{min} = minimum horizontal illuminance at floor level
Uniformity:	$E_{max} : E_{min} \leq 40 : 1$

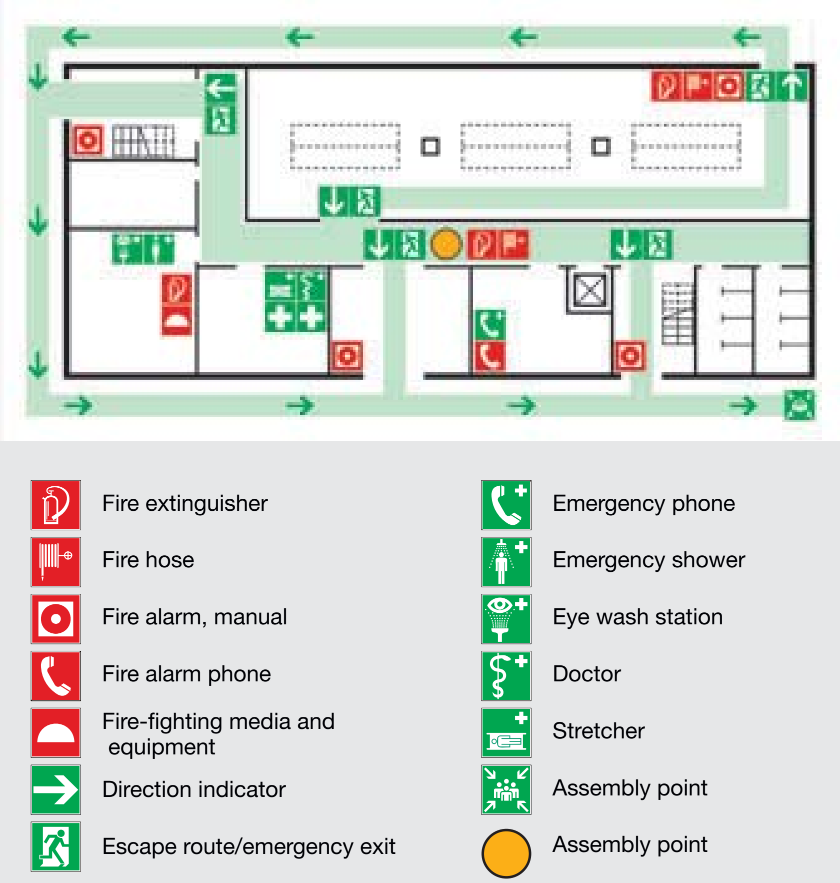
Glare limitation:

h/m	< 2.5	2.5 ≤ h < 3	3 ≤ h < 3.5	3.5 ≤ h < 4	4 ≤ h < 4.5	≥ 4.5
I_{max}/cd	500	900	1,600	2,500	3,500	5,000

The values in this table must not be exceeded at any azimuth angle between 60° and 90° to the vertical.

Colour rendering	$R_a \geq 40$
Nominal operating time for escape routes	1 hour
Power-on delay	50 % of required illuminance within 5 seconds 100 % of required illuminance within 60 seconds

Escape and rescue plan


Fire extinguisher
Fire hose
Fire alarm, manual
Fire alarm phone
Fire-fighting media and equipment
Direction indicator
Escape route/emergency exit
Emergency phone
Emergency shower
Eye wash station
Doctor
Stretcher
Assembly point
Assembly point

16

[16] This ground plan shows a typical escape and rescue plan according to ASR A1.3.

17

[17] Anti-panic lighting helps prevent an outbreak of panic in the event of a power failure.

Anti-panic lighting

Anti-panic lighting is one of three safety lighting sub-groups (see page 4).

The purpose of anti-panic lighting is to reduce the likelihood of panic and create the visual conditions needed to enable people to reach escape routes safely. It needs to be installed where escape routes are not clearly defined – in large halls, for example – or where the entire hall space could be used as an escape route. Anti-panic lighting should be directed straight downwards and illuminate obstacles up to two metres above the reference plane.

DIN EN 1838 criteria

> horizontal illuminance on the open floor no less than 0.5 lx
> ratio of highest to lowest illuminance no greater than 40:1
> colour rendering index R_a of lamps at least 40 to ensure clear identification of safety colours
> nominal operating time for escape routes at least one hour
> 50 % of required illuminance within five seconds, 100 % within 60 seconds
> glare limitation: see table.

Anti-panic lighting (DIN EN 1838)

Illuminance	E (horizontal at floor level) ≥ 0,5 lx. Perimeter areas 0.5 m wide are not taken into account.
Uniformity:	$E_{max} : E_{min} \leq 40 : 1$

Glare limitation:

h/m	< 2.5	2.5 ≤ h < 3	3 ≤ h < 3.5	3,5 ≤ h < 4	4 ≤ h < 4.5	≥ 4.5
I_{max}/cd	500	900	1,600	2,500	3,500	5,000

The values in this table must not be exceeded at any azimuth angle between 60° and 90° to the vertical.

Colour rendering	$R_a \geq 40$
Nominal operating time for escape routes	1 hour
Power-on delay	50 % of required illuminance within 5 seconds 100 % of required illuminance within 60 seconds

Particularly hazardous workplaces

Safety lighting for particularly hazardous workplaces is one of three safety lighting sub-groups (see page 4). Whether and to what extent a workplace is particularly hazardous is established by making a hazard assessment.

Employers in Germany are required to assess working conditions under the Occupational Protection Act; the details are dealt with in paragraphs 5 and 9.

Workplaces may be particularly hazardous, for example,

> in areas where insufficiently secured hot baths, melting or dip tanks, pits or similar hazards are situated,
> in areas where hot masses are transported by non-illuminated lifting gear or non-illuminated industrial trucks,
> at places where explosive, highly toxic, highly caustic or severely irritating substances or open radioactive substances are handled, unless the power supply is connected so that if the power for the general lighting fails, the power is also cut off for the equipment operated at these workplaces,
> at workplaces with fast running machines and unguarded large moving masses that could stay in motion after a power failure, e.g. rollers, papermaking machines, centrifuges, rotary presses, open-end textile machines or wire making machines.

Workplaces where failure of the general lighting system presents particular hazards for other persons include

> switchboard galleries or control panels for blast or electric furnaces, converters, sintering plants, rolling trains, continuous furnaces and pickling lines, power stations, chemical plants;
> generator control stations with a significant safety function, e.g. control stations in electrical operating areas, rooms for cooling water pumps, hydraulic equipment, compressors, blast engines;
> workplaces at isolating or regulating equipment which needs to be operated during normal plant operations or when plant operations are disrupted in order to interrupt or terminate production processes safely and thus avoid hazards.

Maintained safety lighting

For compliance with DIN EN 1838, the illuminance provided for such workplaces needs to be 10 % of the general lighting but no less than 15 lx. The required illuminance must be reached within 0.5 seconds. This is possible only with safety lighting in maintained operation. Lighting uniformity at particularly hazardous workplaces should be lower than 10:1. With regard to nominal operating time, care must be taken to ensure that it is at least as long as the hazard period.

Particularly hazardous workplaces (DIN EN 1838)

Illuminance	E_{min} = 10 % of the maintained illuminance required for the task > 15 lx
Uniformity:	$E_{max} : E_{min} \leq 10 : 1$

Glare limitation:

h/m	< 2.5	2.5 ≤ h < 3	3 ≤ h < 3.5	3.5 ≤ h < 4	4 ≤ h < 4.5	≥ 4.5
I_{max}/cd	1,000	1,800	3,200	5,000	7,000	10,000

The values in this table must not be exceeded at any azimuth angle between 60° and 90° to the vertical.

Colour rendering:	$R_a \geq 40$ Safety colours need to be clearly recognised.
Nominal operating time for escape routes	as long as a hazard exists
Power-on delay:	0.5 seconds

18

Standby lighting

Standby lighting is the second type of emergency lighting alongside safety lighting (see page 4).

19

Standby lighting systems are installed e.g. for operational reasons, to avoid production downtime due to a failure of the general artificial lighting.

If a standby lighting system is to perform the tasks of emergency lighting, it needs to meet all the requirements of DIN EN 1838. Essential activities can then continue. However, if the lighting level is lower than the minimum illuminance of the general lighting, the standby lighting may be used only to power down or terminate a work process.

[18+19] Standby lighting prevents production downtime in the event of the general artificial lighting system failing due to a power outage.

Safety signs: quality is crucial

Safety signs for escape routes can be either *illuminated* safety signs, i.e. with an external light source, or *back-lit* safety signs (escape sign luminaires) with an internal light source.

General requirements

Various regulations allow the use of both the old and the new pictogram (see table): ASR A1.3, health and safety regulation BGV A8 and DIN 4844 require these safety signs for marking escape routes.

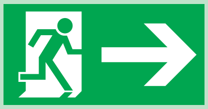
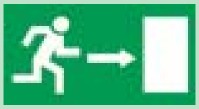
licht.de advises against mixing the two different signs, at least within the same part of a building. From a safety viewpoint, only the escape sign cited in DIN 4844 and ASR A1.3 should be installed in new systems because the direction arrow integrated into the pictogram is presented more clearly.

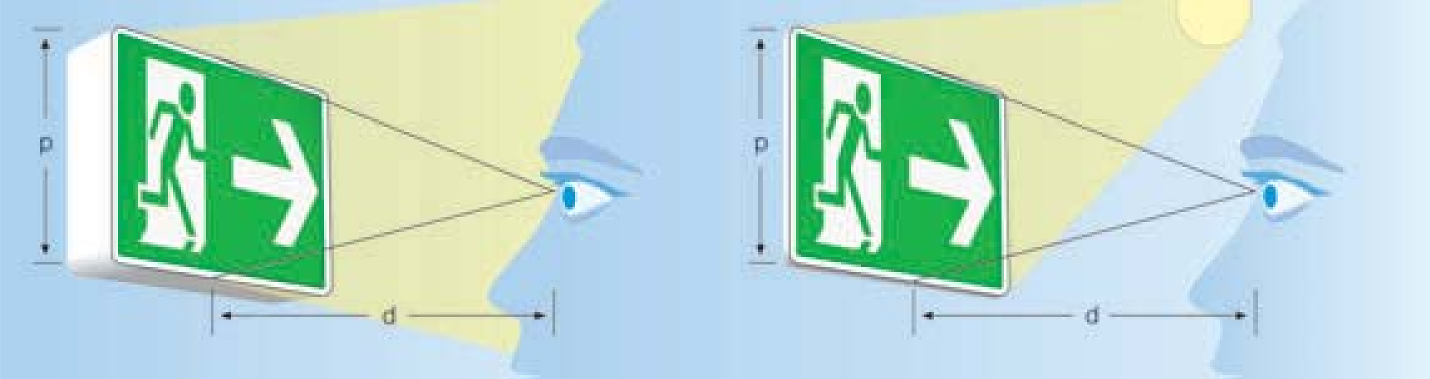
Lighting requirements

DIN EN 1838 and DIN 4844-1 present different requirements for illuminated and back-lit safety signs in terms of the lighting parameters to be met for the different operating conditions. For escape sign luminaires in emergency operation, DIN EN 1838 requires a much lower brightness than DIN 4844-1 for the sign as a whole. DIN 4844-1 deals with normal operation, taking into account that when the general lighting is on, the escape sign needs to stand out against brightly lit surroundings and thus needs to be brighter than in emergency operation. The table on the right summarises the requirements of the two standards.

In the international standard CIE S 020/ ISO 30061 "Emergency Lighting", the lighting requirements for escape sign luminaires in emergency and normal operation are combined in a single document.

Comparison of lighting requirements

	DIN 4844-1	*DIN EN 1838*
Environment	bright and dark	dark
Mains/ emergency power	mains	emergency
Maintained operation	yes	–
Green *safety colour*	acc. ISO 3864-1	acc. ISO 3864-1
White *contrast colour*	acc. ISO 3864-1	acc. ISO 3864-1
Uniformity of green/white surfaces	$g \geq \frac{L_{min}}{L_{max}} 0.2$	$g \geq \frac{L_{min}}{L_{max}} 0.1$
Luminance contrast between green and white surfaces	$k = \frac{L_{white}}{L_{green}} = 5:1$ to $15:1$	
Average luminance of *white* contrast colour	≥ 500 cd/m²	–
Luminance of *green* safety colour	–	≥ 2 cd/m²
Calculated average luminance of *the sign as a whole*	≥ 200 cd/m²	≥ 5 cd/m²
Illuminance of the illuminated sign	≥ 50 lx (preferably ≥ 80 lx)	–
Graphic symbol		



The formula for calculating the height of *back-lit* signs is:

$p = \frac{d}{s}$ $s = 200$

e.g. height = 15 cm ≙ recognition distance 30 m

The formula for calculating the height of *illuminated* signs is:

$p = \frac{d}{s}$ $s = 100$

e.g. height = 15 cm ≙ recognition distance 15 m

Symbols in the formula for calculating sign height

d = recognition distance
p = height of pictogram
s = distance factor 200 for back-lit signs
s = height of pictogram   s = distance factor 100 for illuminated signs

20

21

Height of signs

Because a back-lit sign is easier to recognise from a greater distance than a sign that is only illuminated, DIN EN 1838 and DIN 4844 stipulate that different distance factors need to be applied to establish the relevant recognition distance.

Since illuminated signs have a shorter recognition distance, the pictogram needs to be twice as high as that of a back-lit sign to be equally recognisable at the same distance. Where smoke is present, back-lit signs are recognisable for much longer and from a greater distance.

[21] Safety/escape signs clearly indicate the direction to take – provided the pictogram is correctly dimensioned for the required recognition distance.

Escape sign luminaires for safety

In terms of performance, escape sign luminaires are always a better option than standard photoluminescent signs. There are several reasons for this.

Colour

Escape sign luminaires are easily and correctly identified. The green safety colour is clearly recognisable even in emergency operation. Standard signs with long after-glow photoluminescent pigments, however, appear dark after a power failure: the green safety colour is no longer recognisable as a colour. The white contrast colour generally has a yellowish green appearance.

Effectiveness

Emergency powered luminaires operate regardless of the operational status of the general lighting. Photoluminescent materials, on the other hand, need to be sufficiently and continuously charged ahead of an emergency. Light sources with a predominantly red spectral content (e.g. incandescent lamps) and high-pressure sodium vapour lamps are not suitable sources for charging.

Luminance

The luminance of a luminaire remains constant from the beginning to the end of the nominal operating time, which is generally one or three hours. The impression of brightness generated by a photoluminescent sign, however, diminishes within minutes. After 60 minutes of operation, the luminance of an escape sign luminaire is significantly greater than that of a photoluminescent sign.

Recognition distance

As luminance decreases, so does visual acuity and identifiability. A 20 centimetre high escape sign luminaire is clearly identifiable from a distance of 40 metres; an illuminated escape sign of the same height achieves the same degree of identifiability up to a distance of 20 metres.

By contrast, the afterglow of a similarly sized photoluminescent signs weakens so much in 10 minutes that the recognition distance is only around five metres; after an hour, the content of the sign can be recognised only from right in front of the sign. With an escape sign luminaire, the recognition distance remains constant throughout.

Safety lighting required

"Photoluminescent safety guidance systems do not meet the requirements in terms of colour rendering or illuminance. They can only be used in conjunction with a standard-compliant safety lighting system, e.g. as floor markings, or as a supplementary safety measure in areas where safety lighting is not required."

Runner 68 in Opfermann, Streit, Pernack commentary on the 2004 Workplace Ordinance (ArbStättV)

[22] Escape sign luminaire in maintained operation – luminance of the white contrast colour: 500 cd/m²

[23] … 10 minutes after power failure; luminance of the white contrast colour: 25 cd/m²

[24] … 30 minutes after power failure; luminance of the white contrast colour: 25 cd/m²

[25] … 60 minutes after power failure; luminance of the white contrast colour: 25 cd/m²

[26] Standard long after-glow photoluminescent sign exposed to a charging light source – luminance of the white contrast colour: 40 cd/m²

[27] … 10 minutes after power failure; luminance falls to a level well below that required for compliance with DIN EN 1838.

[28] … 30 minutes after power failure

[29] … 60 minutes after power failure

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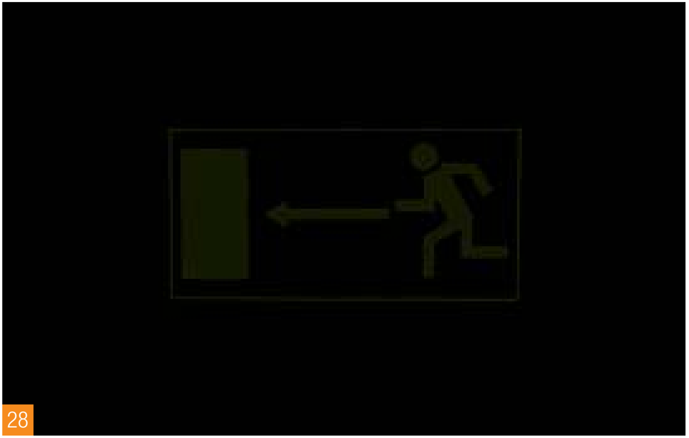
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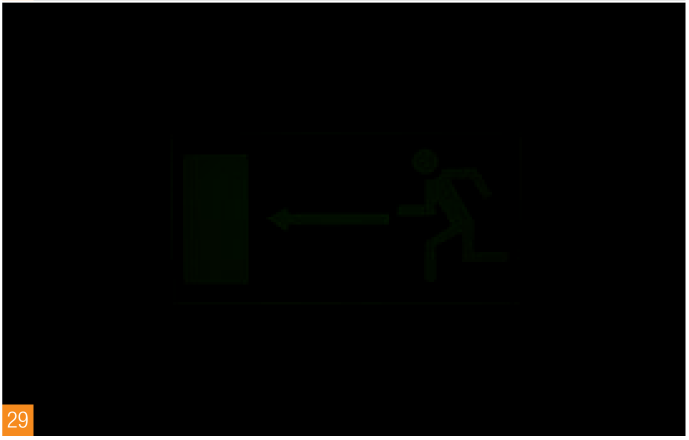

29

Luminaires for safety lighting systems

The light provided by luminaires for safety lighting systems helps ensure that potentially hazardous work operations can be terminated safely and/or the rooms in question evacuated without risk in the event of a general power failure.

The requirements that safety luminaires need to meet in terms of design and operational reliability are set out in the following standards:
DIN EN 60598-1 Luminaires – General requirements and tests,
DIN EN 60598-2-22 Particular requirements – Luminaires for emergency lighting,
DIN EN 62034 Automatic test systems for battery powered emergency escape lighting.

Manufacturers are required to display the CE symbol on luminaires. In doing so, they state on their own responsibility that all the relevant European directives have been observed. The ENEC symbol, which is acquired on application, is the European safety test symbol for luminaires. Documenting that the product conforms to the relevant standards, it is awarded by independent test and certification institutes in Europe. In Germany, this is the VDE (identification no. 10).

Quality luminaires

As well as qualifying for a safety test symbol, a quality luminaire for safety lighting needs to meet the following criteria:

> reliable performance in an emergency,
> light distribution tailored to ensure optimal illumination of the escape sign or escape route,
> low energy-efficient consumption during mains and emergency operation,
> easy mounting and maintenance with correspondingly low costs,
> suitability for recycling at end of service life.

Safety luminaires need to be installed for escape route illumination or for anti-panic lighting in addition to route-marking escape sign luminaires. This lighting can be realised by

1. dedicated safety luminaires with beam spreads tailored for the task or
2. luminaires which are normally used for general lighting – e.g. specular louver luminaires – and which act as safety luminaires in the event of a power failure.

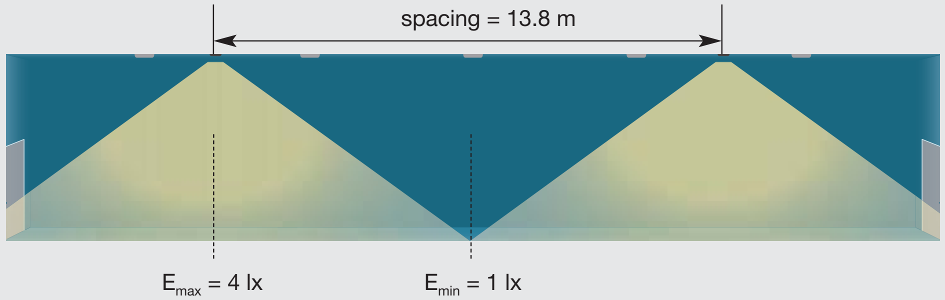
Dedicated safety luminaires – *Variant A* (Fig. 30) – meet all quality criteria:

> The light is distributed in a wide-angled beam.
> The required uniformity is achieved with luminaires at widely spaced mounting points.
> The lamps used – e.g. ∅ 16 mm 8 W linear fluorescent lamps – have a low power consumption rating.

Because installing separate safety luminaires means additional installation costs, some operators favour dual-purpose luminaires that provide both general and safety lighting – *Variant B* (Fig. 31). The disadvantage is that these luminaires are not designed specifically for safety lighting, so they do not offer an optimal beam spread for emergency operation. Consequently, more luminaires than necessary need to be incorporated into the safety lighting to achieve the lighting uniformity required along escape routes. Energy consumption – and therefore the emergency power capacity required – is also many times higher than with Variant A. Where ∅ 16 mm 8 W linear fluorescent lamps might suffice for Variant A, for example, ∅ 26 mm 58 W models are required for Variant B.

Another possible option – one which avoids the disadvantages of Variant B while still allowing the safety lighting to be integrated neatly into the architecture – is *Variant C* (Fig. 32). Here, small dedicated emergency luminaire modules are built into general lighting luminaires.

Variant A: dedicated safety luminaires



$g_2 = E_{min}/E_{max} = 1/4$; $P_{Lamp} = 2 \times 8$ W = 16 W; height of corridor: 3 m

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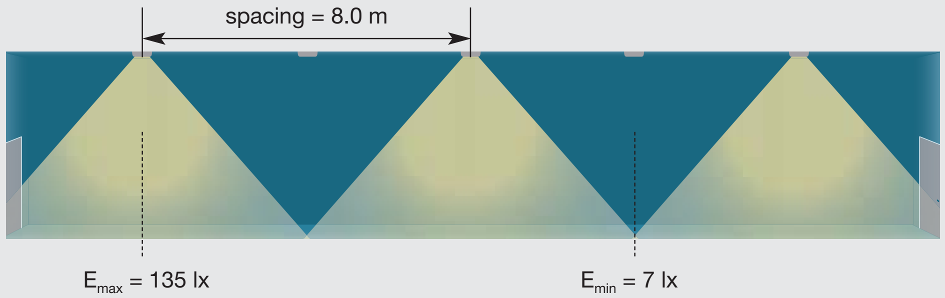
Variant B: general lighting luminaires as safety luminaires



$g_2 = E_{min}/E_{max} = 1/19$; $P_{Lamp} = 3 \times 58$ W = 165 W; height of corridor: 3 m

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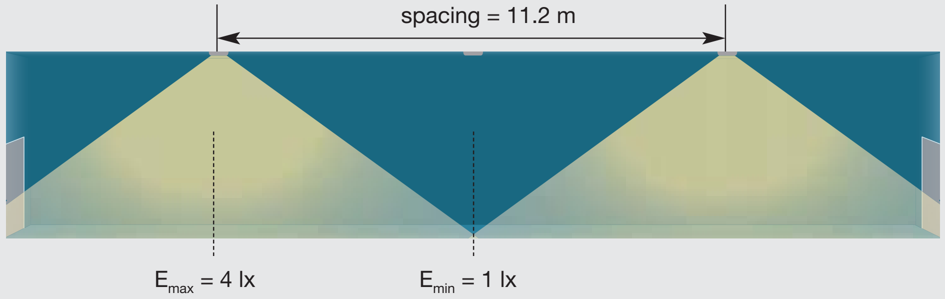
Variant C: “Dual” luminaire with built-in emergency luminaire module



$g_2 = E_{min}/E_{max} = 1/4$; $P_{Lamp} = 2 \times 3$ W = 6 W; height of corridor: 3 m

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With this option, it is important to make sure that the “dual” luminaires are made by an established manufacturer. Retrofitting, e.g. by an electrician, always amounts to a structural modification of the original luminaire and thus invalidates the CE symbol and ENEC test symbol of the luminaire.

Retrofitting or altering general lighting luminaires for service as safety luminaires (Variant 2) also counts as a modification that can invalidate a product licence. This can include integrating

> emergency EBs to reduce luminous flux and energy consumption in emergency operation,
> changeover modules for switching between mains and emergency power supply,
> individual battery packs as an emergency power source for the luminaire in the event of a power failure.

Safety lighting with

[30] dedicated safety luminaires
[31] general lighting luminaires used as safety luminaires
[32] integrated emergency luminaire modules – built into general lighting luminaires by the luminaire manufacturer (“dual luminaire”)

Safety lighting operation

If mains power fails, an alternative energy source needs to be provided to power the safety lighting. Battery systems, generating sets or a specially secured network (E DIN VDE 0108-100, see page 35) are suitable options.

For the alternative energy source to power safety lighting, a distinction is made between three modes of connection:

> Non-maintained operation

The safety luminaires are activated only in the event of a power failure. This mode of connection may be used for escape route lighting in all types of building.

> Maintained operation

The safety luminaires are permanently activated. Maintained operation is the option allowed for escape sign luminaires.

> Switched maintained operation

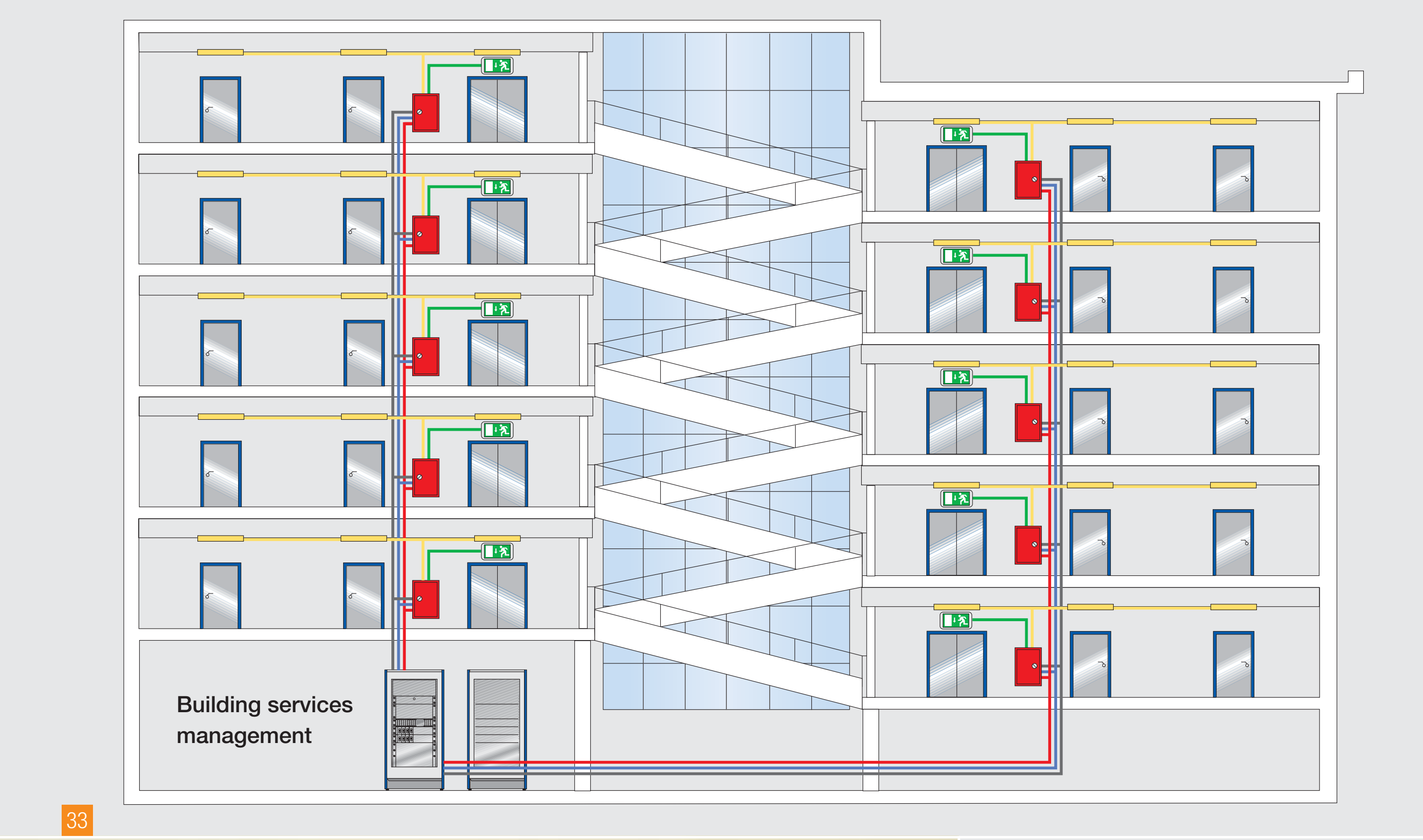
The safety luminaires are activated and deactivated together with the general lighting luminaires.

The switch-over from normal operation to the power source for safety lighting must occur if the line voltage exceeds the nominal rated voltage by 15 % for more than 0.5 seconds. When mains power returns, the safety lighting must stay on for at least another minute, except in assembly rooms that are darkened for operational purposes and in facilities in which the light sources used for general lighting – e.g. high-pressure discharge lamps – have relatively long starting times.

Alternative power sources

Battery-operated central power supply systems need to comply with DIN EN 50171, single battery luminaires with DIN EN 60598-2-22. Generating sets (diesel) need to meet the requirements of ISO 8528-12, while DIN VDE 0100-560 applies to specially secured networks.

	Battery power supply
Central power supply system with no restriction on output power (CPS))	Any battery voltage, preferably 216 V lead: 2.0 V / cell NiCd: 1.2 V / cell life: min. 10 years
Central power supply system with a limitation on output power (LPS)	Any battery voltage, preferably 24 or 48 V lead: 2.0 V / cell life: min. 5 years max. 1,500 W for 1 hour max. 500 W for 3 hours
Individual battery	NiCd: 1,2 V / cell Blei: 2,0 V / cell life: 4 years


Building services management

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[33] Central battery system for safety lighting

[34] Batteries provide the power lost in the event of mains failure

[35] Central battery system

Batteries

In line with the Ordinance Governing the Return of Spent Disposable and Rechargeable Batteries, spent batteries need to be treated as recyclable waste subject to special supervision. These batteries, displaying both the recycling symbol and the crossed-out waste bin, must not be disposed of as residual or household waste. Their return and recycling must be agreed with the relevant manufacturer.

Deep discharge protection prevents the battery being completely drained: when the minimum permissible voltage is reached, the consumer is automatically disconnected. Even though very little power is required for the electronics, it is necessary to avoid the batteries becoming fully discharged after long periods out of operation.

Power failure simulation

A power failure simulation test button must be located on the single-battery luminaire, on the supply lead to the luminaires or on the central power supply system. Hand-operated test buttons must return automatically to their original position.

Status displays

Status displays and monitoring devices depend on the type of emergency lighting system installed. With single-battery luminaires, an indicator light shows that they are being charged. For central battery systems, various status displays are required to provide information on battery voltage, charging current, load current, power source and malfunctions.

Special features

In the case of single and central power supply systems, a central remote control facility is required to prevent batteries being drained when idle. Safety lighting management and BUS systems need to be independent of general lighting management and BUS systems.

Inspection

The law requires that safety systems must be regularly inspected and maintained. This includes safety lighting. Depending on the premises concerned – e.g. a stairwell without daylight incidence – even the failure of a single safety or escape sign luminaire presents a serious risk of accident.

The safety lighting inspection regime must include the following:

> daily visual examination of the central power supply unit;
> weekly inspection of the safety lighting system with safety power source connected, checking the functional status of all luminaires;
> monthly inspection of the unit monitoring the central battery system;
> annual inspection of the charging unit as well as the battery capacity for the rated service time;
> logs of the regular inspections need to be kept to permit retroactive monitoring over at least four years.

Where an automated inspection and test system (acc. DIN EN 62034) is used, an annual manual function check on the appliances is sufficient. It therefore makes sense to integrate these tasks into a central, comprehensive visualisation.

Central monitoring systems

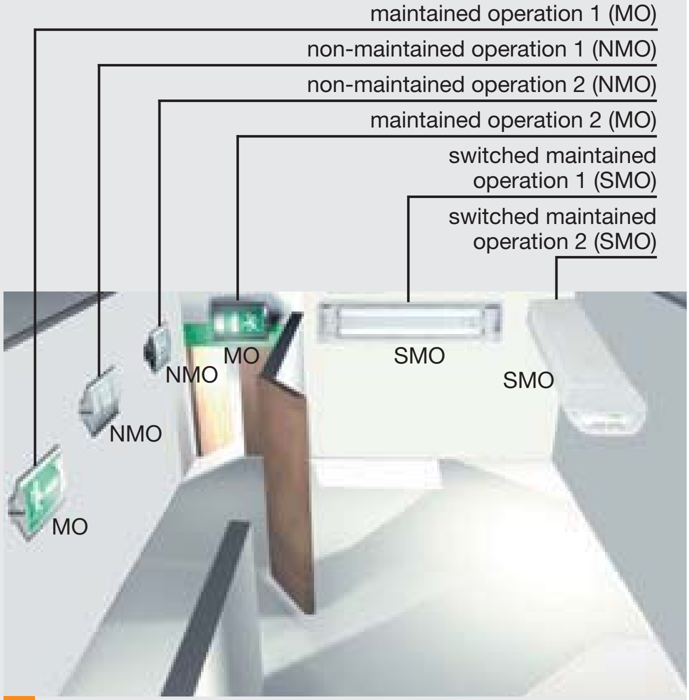
Depending on manufacturer, the signals from individual monitored luminaires are transmitted via a special BUS line or directly via the power supply line.

Where the power supply line provides the link, special electronic ballasts (EBs) transmit a noise-free pulse straight down the power line to the central monitoring unit via their individual controllers. Where standard EBs are used, this task can be performed by a separate monitoring module.

The relevant status features can be centrally accessed to show the functional state of luminaires, cable routes, subdistribution boards and battery systems with location descriptions. A standard compliant electronic log of the automatic verifications carried out is centrally maintained. Even remote monitoring via intranet or Internet presents no problems.

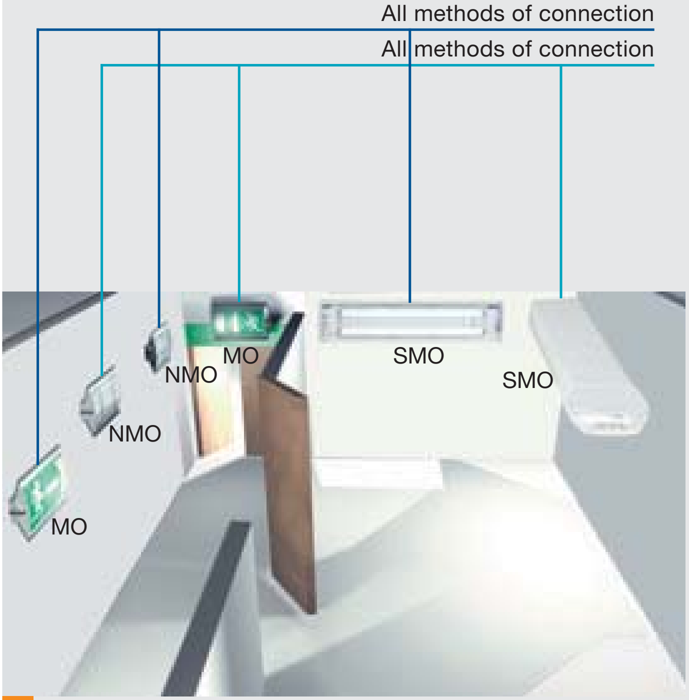
In larger buildings, central monitoring “down to the last luminaire” is recommended for reasons of economy. Member companies of the German Electrical and Electronic Manufacturers’ Association (ZVEI) offer systems which can be integrated in the building services management system and adapted on a project-by-project basis to suit the number and type of luminaires deployed as well as the power source used for safety system operations.

Conventional installation

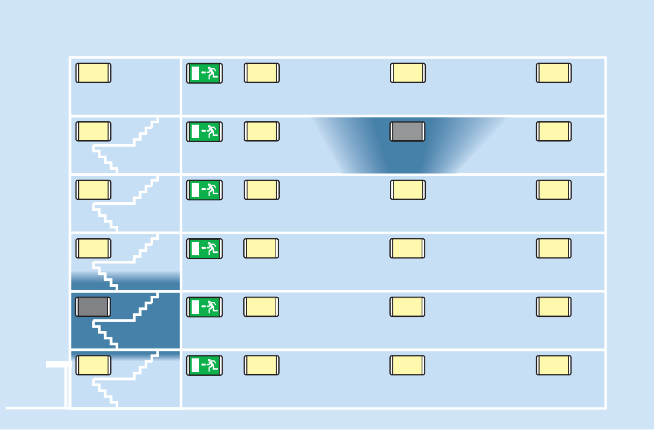

maintained operation 1 (MO)
non-maintained operation 1 (NMO)
non-maintained operation 2 (NMO)
maintained operation 2 (MO)
switched maintained operation 1 (SMO)
switched maintained operation 2 (SMO)
MO
NMO
SMO
SMO
NMO
MO

36

All methods of connection in one circuit (mixed operation)


All methods of connection
All methods of connection
MO
NMO
SMO
SMO
NMO
MO

37



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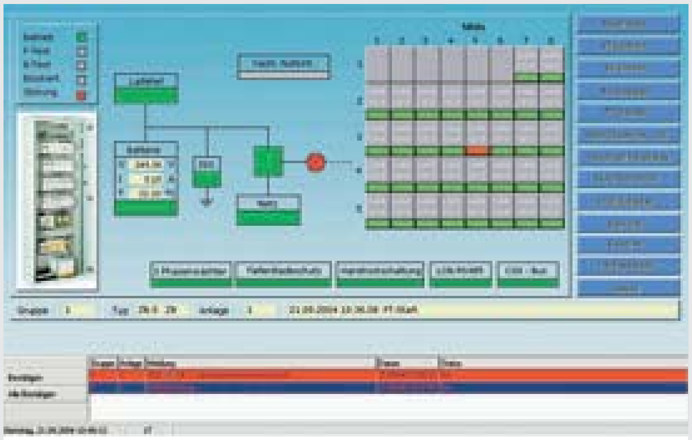

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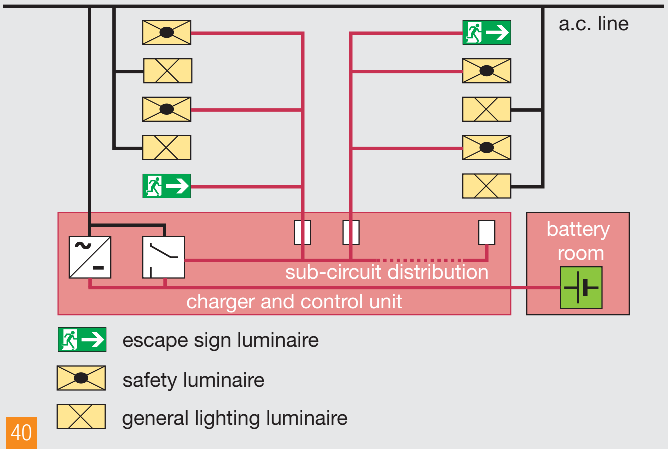
Example of a safety lighting system with central battery


a.c. line
battery room
sub-circuit distribution
charger and control unit
escape sign luminaire
safety luminaire
general lighting luminaire

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[38] If even a single safety luminaire fails, there is a risk to human life.

[39] Screenshot of an automated inspection and test system

Application examples

All ordinances, directives and regulations require safety lighting where general lighting system failure presents an evident risk of accident.

But ordinances, directives and regulations set out only minimum requirements. Experts all agree that even where rules and standards do not apply, safety lighting should be installed wherever there is a risk of accidents.

In Germany, safety lighting is a matter regulated by the building regulations of the federal states. These stipulate where safety lighting must be installed. In certain cases, additional requirements may need to be met to secure planning permission or other official approvals and expertises may need to be obtained, e.g. on fire protection or panic risk.

The application examples here describe solutions based on model ordinances and guidelines whose contents may differ from the federal state ordinances and directives in force. They are also based on the standard DIN EN 1838, which applies right across Europe, as well as the draft standard E DIN VDE 0108-100, which is recommended for application.

Places of assembly

Places of assembly are defined in the Model Ordinance Governing Places of Assembly (MVStättV) adopted in June 2005 as facilities or parts of facilities built to accommodate large numbers of people simultaneous attending events, especially educational, commercial, social, cultural, artistic, political, sports or entertainment events, as well as catering establishments. Sports facilities (page 29) and restaurants (page 26) are dealt with separately in this booklet because additional requirements need to be met in each case.

A place of assembly can also consist of a number of assembly rooms if these are interconnected within a building by doors or common escape routes.

The MVStättV covers

> assembly rooms which singly or jointly accommodate at least 200 persons, e.g. assembly halls, foyers, lecture theatres, cinemas and studios but not classrooms in schools;
> places of assembly for at least 1,000 persons with open performance areas – areas less than 20 m² are not classed as performance areas;
> sports stadiums accommodating more than 5,000 spectators with stands for visitors and with non-roofed sports areas.

The MVStättV does not cover rooms reserved for religious services, exhibition rooms in museums, temporary buildings.

Visitor numbers are calculated on the basis of established formulas:
> for seating at tables: one visitor per m² of assembly room floor area,
> for seating in rows and for standing space: two visitors per m² of assembly room floor area,
> for standing space on terraces: two visitors per metre of terrace length,
> for exhibition rooms: one visitor per m² of assembly room floor area.

Areas which are not open to visitors are not included in the calculations.

Safety lighting

Safety lighting needs to be provided

> in necessary stairwells, in rooms between necessary stairwells and external exits and in necessary corridors;
> in assembly rooms as well as in all other rooms for visitors (e.g. foyer, cloakroom, toilets);
> for stages and performance areas;
> in rooms for participants and employees with a floor area of more than 20 m², excluding offices;

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FERROZELL

> in electrical operating areas, in rooms for building service installations as well as in lighting and projector rooms;
> in outdoor places of assembly and sports stadiums used at night;
> for safety signs marking exits and escape routes;
> for step lighting, but not in the case of corridors in assembly rooms with changeable seating configurations or in the case of stadiums with safety lighting.

In assembly rooms that are darkened for operational purposes, on stages and in performance areas, safety lighting needs to be available on standby.

What DIN VDE 0108 sets out as a mandatory requirement is still recommended: non-maintained safety lighting must not automatically switch off when mains power returns. Systems installed in rooms that are darkened for operational purposes are required to have manual resets on the safety lighting control panel and at another point in the control room. The safety lighting must not be deactivated until sufficient general lighting has been restored. Exits, corridors and steps in an assembly room must be identifiable even when the room is darkened, regardless of whether the other safety lighting is activated or not.

[41] Escape route marking and safety lighting in places of assembly reduce the risk of accidents in the wake of a general lighting failure.

Restaurants

The Model Ordinance Governing Places of Asssembly (MVStättV) adopted in June 2005 also covers catering establishments, so bars or restaurants accommodating more than 200 guests need to meet the same safety lighting requirements as other places of assembly (see page 24).

The number of guests that can be accommodated is calculated on the basis of the following formula:
> for establishments with seating: one visitor per m² of public room floor area (excluding counter area);
> for establishments with 100 m² of standing space or more, e.g. discotheques: two visitors per m² of floor area.

Safety lighting

Safety lighting needs to be provided

> in necessary stairwells, in rooms between necessary stairwells and external exits and in necessary corridors;
> in public rooms as well as in all other rooms for visitors (e.g. foyer, cloakroom, toilets);
> in rooms for operators and staff with a floor area of more than 20 m², excluding offices;
> in electrical operating areas and in rooms for building service installations;
> in outdoor restaurants used at night;
> for safety signs marking exits and escape routes;
> for step lighting, but not in the case of corridors in public rooms with changeable seating configurations.

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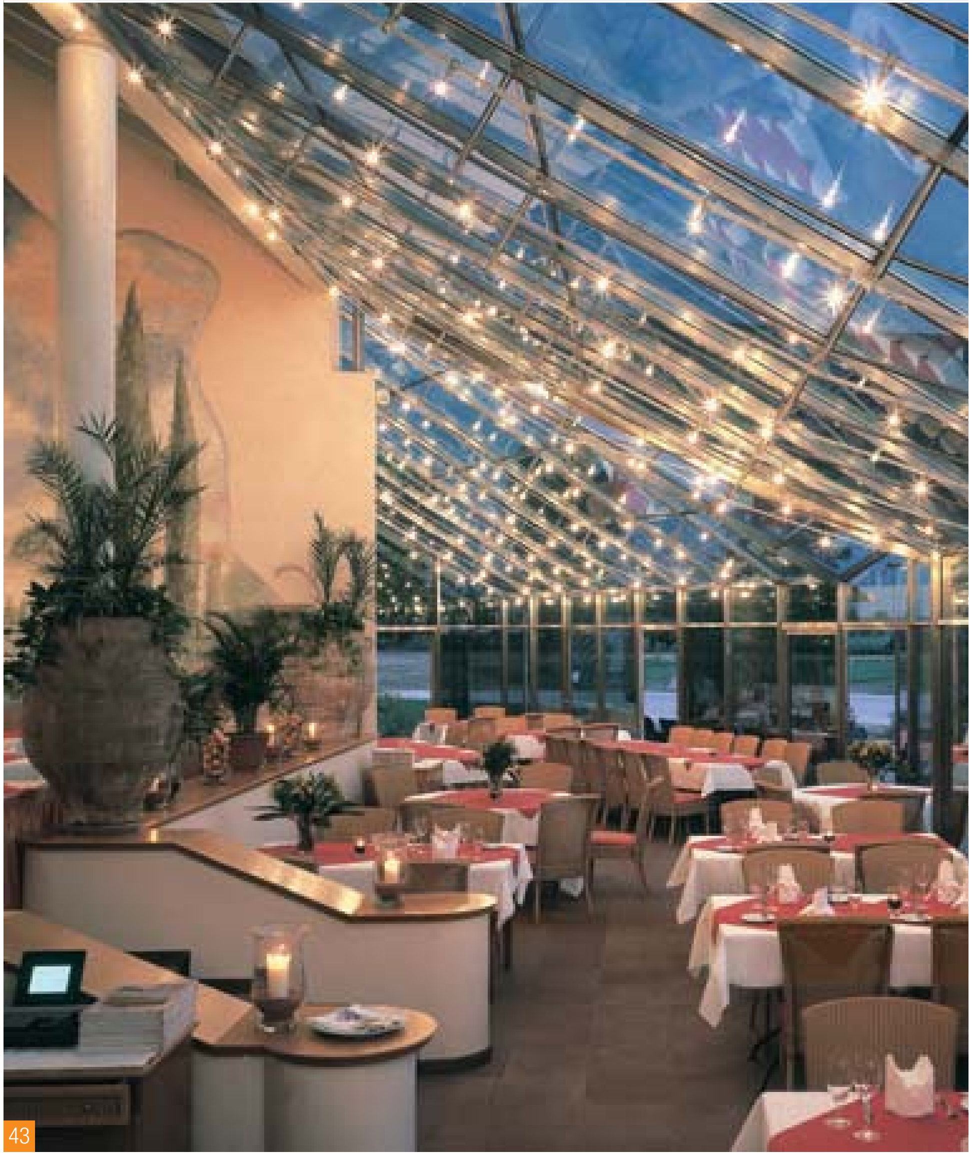
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[42 + 43] Restaurants are places of assembly governed by the MVStättV.

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Sales premises

Sales premises – often referred to as stores in earlier standards – are defined in the Model Ordinance Governing Sales Premises (MVkVO) adopted in September 1995 as buildings or parts of buildings

> which are used wholly or partially for the sale of merchandise;
> which have at least one salesroom;
> which are not trade fair buildings.

The MVkVO covers all sales premises – both retail and wholesale and from department stores to supermarkets, to shopping centres – incorporating salesrooms and shopping streets, including their built structures, with a total area of more than 2,000 m². Shopping streets are defined as enclosed or covered areas which are flanked by salesrooms and act as circulating areas for shoppers.

Safety lighting

Safety lighting needs to be provided

> in salesrooms;
> in stairwells, stairwell extensions and shopping streets as well as in corridors needed for shoppers;
> in work and break rooms for staff;
> in toilet facilities with a floor area of more than 50 m² – in Bavaria and Brandenburg in toilet facilities of any size;
> in electrical operating areas and in rooms for building service installations;
> for signs indicating exits and for step lighting.

Health and safety rule BGR 216 of July 2001 contains different stipulations, requiring safety lighting for work rooms and salesrooms with an area of more than 500 m² and a high ratio of visitors to staff.

[44 + 45] For sales premises (> 2,000 m² floor area) – generally referred to as stores in earlier standards – safety lighting is a vital requirement.

Accommodation establishments

The Model Ordinance Governing Accommodation Establishments (MBeVO) adopted in December 2000 defines accommodation establishments as all buildings with more than 12 beds for guests. The MBeVO does not apply to accommodation establishments in high-rise buildings.

Safety lighting

Safety lighting needs to be provided

- in necessary corridors and necessary stairwells;
- in rooms between necessary stairwells and external exits;
- for signs indicating exits;
- for steps in necessary corridors.

E DIN VDE 0108¬100 requires that where the rated service time of the power source for safety systems is only three hours, switched maintained operation should be provided in conjunction with illuminated pushbutton switches and timed lighting. The safety lighting must automatically switch off after the pre-defined time has elapsed. If not, the capacity of the power source for safety systems needs to be designed for 8 hours operation.

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[46 + 47] Accommodation establishments: safety lighting is required for all buildings with more than 12 beds for guests.

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Sports facilities

Sports facilities fall within the scope of the Model Ordinance Governing Places of Assembly (MVStättV) adopted in June 2005. Sports stadiums are places of assembly with stands for visitors and non-covered areas for sporting activities. The MVStättV applies to sports stadiums designed to accommodate more than 5,000 visitors.

Because the distinction between 'sport' and 'performance' is becoming increasingly blurred, the requirements may also apply to outdoor sports facilities if they

> are designed to accommodate more than 1,000 visitors,

> feature performance areas and

> the visitor area consists entirely or partly of built structures.

Visitor areas bounded by barriers consist "entirely or partly of built structures" and thus fulfil this criterion.

Safety lighting

Apart from the requirements of MVStättV, sports facilities are also governed by DIN EN 12193. This standard requires safety lighting for participants in sporting events.

Where an event can be brought to an orderly conclusion, the safety of participants is assured. Ending it without lighting entails considerable risk of accident. The safety lighting required thus needs to respond "instantly".

The level of safety lighting required depends on the type of sport in question; it is expressed as a percentage of the lighting level normally required for the sport:

> swimming – 5 % for at least 30 seconds

> gymnastics, indoor facility – 5 % for at least 30 seconds

> equestrian sports, indoor and outdoor facility – 5 % for at least 120 seconds

> speed skating – 5 % for at least 30 seconds

> bobsleigh and luge – 10 % for at least 120 seconds

> ski-jumping, take-off and landing zone – 10 % for at least 30 seconds

> downhill skiing – 10 % for at least 30 seconds

> cycling (track racing) – 10 % for at least 60 seconds.

For swimming pools with a depth of 1.35 m or more, the Pool Construction Guideline (1996) requires safety lighting to provide 15 lux illuminance at the water surface.

[48] Sports facilities are places of assembly – and also subject to the requirements of DIN EN 12193.

Tall and high-rise buildings

According to paragraph 35 of the Model Building Regulations (MBO) adopted in November 2003, buildings more than 13 metres high (tall buildings) also require safety lighting in necessary stairwells, necessary corridors and elevator lounges. In the past, these requirements applied only to high-rise buildings, which the MBO defines as buildings over 22 metres high.

In both cases, height is measured from ground level to the finished floor level of the highest storey suitable for accommodation.

Safety lighting

In a high-rise residential building, E DIN VDE 0108-100 requires that where the rated service time of the power source for safety systems is only three hours, switched maintained operation should be provided together with illuminated pushbutton switches and timed lighting. The safety lighting must automatically switch off after the pre-set time has elapsed. If not, the capacity of the power source for safety systems needs to be designed for 8 hours operation.

Aside from these stipulations, various federal states in Germany have regulations setting out special or more stringent requirements for high-rise buildings.

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[49 + 50] Tall buildings (over 13 metres high) and high-rise buildings (over 22 metres high) require safety lighting regardless of whether they are designed for office or residential occupancy.

Enclosed parking facilities

The Model Ordinance Governing Parking Facilities (MGarVO) adopted in September 1997 requires safety lighting for all indoor parking facilities with a net area of more than 1,000 m² except for single-storey parking facilities with regular users. The net area of a parking facility is the sum of all interconnecting parking spaces plus circulation areas.

Escape routes generally include:

> driving lanes
> pathways alongside vehicle entrances and exits
> staircases and routes leading to pedestrian exits.

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PARKHAUS MARKT
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← AUSGANG + LIFT

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Aufzug-Treppenhaus
KASSENAUTOMAT
E

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[51 – 53] Safe parking: safety lighting is required for enclosed parking facilities (> 1,000 m² net area).

Schools

The Model Guideline for School Buildings (MSchulbauR) adopted in July 1998 applies to general and vocational schools, provided they are not used exclusively for adult education. However, the guideline does not cover universities, higher technical colleges, academies, adult education centres, music, dance or driving schools or educational establishments of a comparable nature.

The MSchulbauR requires safety lighting in necessary corridors, necessary stairwells and windowless common rooms.

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[54 + 55] Safety lighting is required for general and vocational schools, provided they are not used exclusively for adult education.

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Hospitals

DIN VDE 0100-710 requires safety lighting for various areas in hospitals and clinics, doctors' and dental surgeries and medical supply centres. Safety lighting is necessary for

> escape routes,
> escape signs,
> rooms with switchgear assemblies > 1kV,
> rooms with switch and control gear, power sources for safety systems, main distribution boards for general and safety power supply,
> rooms where vital services are maintained, and
> Group 1 and 2 rooms: for some of the luminaires, at least two different power sources need to be available, one of the circuits being connected to the safety power supply.

Group 1 rooms include examination and treatment rooms, Group 2 rooms operating theatres and intensive care units.

Apart from these stipulations, some federal states in Germany, e.g. North Rhine-Westphalia and Brandenburg, have ordinances setting out additional requirements for hospital buildings.

[56 – 58] Safety lighting is required for nearly every area of a hospital. In some federal states in Germany, additional requirements are set out in special ordinances governing hospital buildings.

Work premises

According to the Workplace Ordinance (ArbStättV) adopted in August 2004, safety lighting for escape routes and emergency exits must be provided as a matter of principle on work premises where the safe evacuation of employees is not guaranteed – especially in the event of general lighting failure. Safety lighting is also required where employees would be exposed to risk of accidents in the event of general lighting failure.

Where safety lighting is required for escape routes, the old workplace regulation ASR 7/4 still applies. “Safety and health signs” are defined in the technical regulation ASR A1.3, “Escape routes, emergency exits, escape and rescue plan” are described in ASR A2.3.

Safety guidance systems

Safety lighting can be usefully supplemented by safety guidance systems. These are installed in addition to (not as an alternative to) safety lighting.

The technical regulation ASR 2.3 states (section 7, subsection 2): “A safety guidance system is required to be installed where a heightened risk exists because of local or operational conditions. A heightened risk may exist, for example, in large interconnecting or multi-storey building complexes, where a large percentage of the persons present are not familiar with the surroundings or where a large percentage of persons present have limited mobility. Such circumstances may require a safety guidance system that responds and indicates the best escape direction if danger threatens.”

Non-electric safety guidance systems must always be charged by a light source. Without light from a general or safety lighting system, they cannot maintain visibility.

Electric safety guidance systems do not require external charging. They are more independent, operate autonomously and are therefore the better alternative. They also permit dynamic indication of changes of direction.

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[59 + 60] Where there is a risk of accident in the wake of general lighting failure, safety lighting is a must. This applies particularly to work premises. Safety lighting can be usefully supplemented (not replaced) by safety guidance systems.

Requirements to be net by electrical installations for safety lighting

according Table A.1 in E DIN VDE 0108-100 (VDE 0108-100):2007-08

Examples of communal facilities	Illuminance, lx	Max. switch-over time, s	Rated service time of power source for safety systems, hrs	Illuminated or back-lit safety signs in maintained operation	Central power supply system – CPS	Power supply system with limitation on output power – LPS	Single-battery system	Generating set, no interruption (0 s)	Generating set, short interruption (≥ 0.5 s)	Generating set, moderate interruption (≥ 15 s)	Specially secured network
Places of assembly (excluding temporary buildings), theatres, cinemas	b)	1	3	•	•	•	–	•	•	–	–
Temporary buildings used as places of assembly	b)	1	3	•	•	•	•	•	•	–	–
Exhibition halls	b)	1	3	•	•	•	–	•	•	–	–
Sales premises	b)	1	3	•	•	•	–	•	•	–	–
Restaurants	b)	1	3	•	•	•	•	•	•	–	–
Accommodation establishments, residential homes	b)	15 a)	8 e)	•	•	•	•	•	•	•	–
Schools	b)	15 a)	3	•	•	•	•	•	•	•	–
Indoor car-parks, underground parking facilities	b)	15	1	•	•	•	•	•	•	•	–
Airports, railway stations	b)	1	3 f)	•	•	•	•	•	•	–	–
High-rise buildings	b)	1 a)	3 d)	•	•	•	•	•	•	•	–
Escape routes on work premises	b)	15	1	• g)	•	•	•	•	•	•	•
Particularly hazardous workplaces	b)	0,5	c)	•	•	•	•	•	•	–	•
Stages	3	1	3	•	•	•	–	•	•	–	–

a) From 1 s to 15 s, depending on panic risk
b) Safety lighting illuminance acc. DIN EN 1838
c) Duration of risk for persons present
d) 8 hrs for high-rise residential buildings if not operated acc. 4.4.8
e) 3 hrs sufficient if operated acc. 4.4.8
f) 1 hr also permissible for overground areas of stations, depending on evacuation concept.
g) Not required for escape routes on work premises

• = permissible   – = not permissible